RECENT PROGRESS IN PARASITOLOGY

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In an address delivered some years ago before this Society, I expressed the view that the problems of medical zoology would acquire increasing interest in the immediate future and this view of the situation has been abundantly justified by events in recent years. So much so that the task which has been laid upon me by the Secretary is a difficult one in view of the mass of material which has been produced. In dealing with recent progress in this field it is possible, within the limits assigned, to include only the major items, and even at that some of those must be passed by with hardly more than a mention. Many investigations of marked value will have to be omitted entirely, although others may appear to have been given an amount of space out of keeping with their real value. But it seems necessary to note particularly those investigations which open up new portions of the field, or which change our point of view or accepted interpretation of an individual subject, rather than those which contribute equally valuable results in the better known portion of the territory. While from one standpoint those papers must be regarded as most valuable which present results obtained from a study of the human species, either directly or in its relations with some other forms of animal life, yet it is evident on a moment's thought that comparative studies are as indispensable for a thorough understanding of the field of medical zoology as they are in other

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portions of the biological field. For commercial reasons those relations which affect the domestic animals have commanded greater attention than those which affect animals of less value to man. Consequently the bulk of the literature concerns itself with a description of the parasites of man and of the domestic animals; nevertheless the smaller number of papers that deal with other forms often contain results of equal or greater value.

The importance of studies in medical zoology has been emphasized in the scientific mind, during very recent years by the establishment of schools of tropical medicine following hard on those which originated very recently also in Liverpool and London. Furthermore, courses in tropical medicine have been introduced into medical colleges at home and abroad. Chairs in parasitology, in protozoology, and in medical entomology have been endowed abroad and have been established under university influences even in our own country. Finally the medical journals are devoting increased attention to the animal parasites and animal carriers of diseases which, only a very few years ago, received but scant attention in their pages or were entirely overlooked.

Some part of this movement is undoubtedly due to the recognition of the scientific importance of problems which previously had been entirely overlooked. But the major part of it is undoubtedly due to the increased importance, in a commercial way, of tropical countries and peoples. It is doubtful whether sleeping sickness would have demanded as wide-spread attention or as strenuous efforts for its suppression if it had not been a grave commercial danger to the nations developing extensive colonial possessions in Africa. It is certainly true that our own increased contact with the Orient has resulted in forcing upon us an interest in the diseases which are primarily characteristic of that territory and which, by virtue of more frequent intercourse, are constantly being brought to our shores and endangering our territory.

The extent to which such diseases affect tropical regions may be readily inferred from the medical reports of those regions. A sample of this evidence is furnished by the records of our insular possessions. The Philippine Bureau of Health reports from Bilbid Prison hospital, during less than two years, 1537 cases of hook worm, 551 cases of amebic disentery, and 174 cases of malaria, out of 2,800 cases, or, about 81% due to animal parasites. They

estimate 80% of the entire population to be infected, a higher percentage of infection than has as yet been definitely reported from any other people. The results are seen in the general physical impoverishment of the people and the high rate of morbidity and mortality charged to other diseases.

Among the general items which demand consideration at the outset one may place first of all those organizations or foundations for the study of the diseases caused by animal parasites or conveyed through their medium. These enterprises have taken various forms, being organized under government control, as parts of universities or educational institutions, or as separate foundations.

Several European governments have organized bureaus or commissions and have sent parties into the field for the investigation of sleeping sickness within the limits of their own territories. Indeed, it is fair to say that no other disease has attracted as much governmental attention as this. Unfortunately the experiments have not as yet yielded very positive results with reference to the possibility of effecting a cure and the problem of prevention is naturally an exceedingly difficult one when applied to peoples who are unaccustomed to exercise any sanitary precautions and are unable to understand the reason for the simplest regulations which are promulgated.

The French Commission for the study of Sleeping Sickness in the French Congo published in 1909, an extended and careful report on the disease and its transmitting agents in that region. The report abounds in valuable data, far too extensive to be abstracted here. The German Commission which was sent to German East Africa published its report in the same year. The work is characterized by genuine German thoroughness and is magnificently illustrated. The Sudan Sleeping Sickness Commission also published its final report during the same year and this again contains valuable contributions to the knowledge of the disease-producing and the disease-transmitting organisms. Prominent mention should also be made of the Sleeping Sickness Commission of the Royal Society of London, England, to the work of which reference is made in detail later.

A most important movement in connection with the suppression of this disease, produced and transmitted by animal organisms, was the organization of the Sleeping Sickness Bureau in Lon-

don under the direction of the most eminent English investigators of tropical diseases and of leading Colonial officials of the Imperial government. The Bureau began in 1908 the publication of a Bulletin giving prompt and accurate reports of field work and of laboratory experimentation on the trypanosomes which produce this and similar diseases, the flies which carry them, the chemical substances employed in therapeutic experiments, and the means of all sorts for attacking, limiting, or eradicating the disease in man. These splendid reports have been supplemented by advisory pamphlets for travelers and residents in tropical Africa, by maps showing the known distribution of the disease and its carriers, and by an exhaustive Bibliography of Trypanosomiasis.

The permanent Commission for the Suppression of Uncinariasis in Porto Rico closed its work in 1909 since the legislature failed to appropriate the necessary funds for its continued activity. This agency reached 81,375 persons in 1908 and as a result of the treatment given 25,757 of them were entirely freed of hookworms. The full meaning of the work done by the Commission may be grasped when one compares the health reports of Porto Rico and finds a drop in deaths due to anemia from 11,875 during 1900-01 to 1,785 during 1907-08.

The foundation in our own country of a commission for the suppression of hookworm disease deserves special mention since it is the first instance in which large private funds have been given to an organized movement for the suppression of disease caused by an animal parasite. The stimulus which has been given to work throughout the infected territory, and the results already attained with reference to the prevalence of the disease, the conditions which favor its spread and those which limit it, and the prophylactic measures which should be inaugurated and can be promulgated, are abundant justification of the wisdom which prompted the gift and the skill which has accompanied the organization of the work under the direction of the commission.

While the government has detailed a part of the time of one of its officers in connection with the work of this commission, it is noteworthy that the work represents otherwise the results of private activity and as such is unique in the scope of its operations and in the magnitude of the results it seeks to achieve.

The organization in London of a Society for the Destruction of Vermin, and the demand for information concerning such pests as shown by articles in newspapers and popular magazines, both indicate the growth of a serious public movement to reduce the numbers of these undesirable elements of the fauna which play a prominent part in the transmission of disease.

From general literature evidences of the movement may be cited in the establishment in 1908 of a section of the Journal of Hygiene which was named Parasitology and devoted exclusively to problems connected with animal parasites and the diseases with which they are related.

The foundation in 1907 of the Annals of Tropical Medicine and Parasitology by the Liverpool School of Tropical Medicine has furnished another medium for the adequate publication of memoirs in the field under consideration. Most of the articles published in it present the results of investigations in medical zoology and their high character together with the effective appearance of the publication renders it a most important aid to research in this field.

The foundation by the Instituto Oswaldo Cruz in Rio de Janeiro of a series of Memorias also deserves especial mention. The monographs deal largely with medical zoology. They are uniformly important research contributions in this field and are printed and illustrated in a manner worthy of their character.

The Wellcome Research Laboratories founded several years ago at the Gordon Memorial College in Khartoum, had as one of its primary functions the investigation of problems in parasitology. The third annual report (Balfour, 1908) is a series of splendid articles on protozoology, helminthology, and medical entomology, and contributes in a most valuable manner to both general and local parasitology. The supplement to this report includes a review of recent advances in tropical medicine which in admirably clear and succinct form presents *inter alia* the results of investigations in medical zoology. This review covers recent work in parasitology about up to the time at which the present paper begins; in that, however, the material is grouped under the head of the various diseases produced and emphasis is laid on the clinical and pathological aspects rather than on the structural and biological features which alone are considered here. One may hope that a

publication so valuable and so satisfactorily printed, may receive the support necessary for its perpetuation.

Undoubtedly the greatest bibliographic work yet undertaken in this field is the publication by the U. S. Department of Agriculture of the Index Catalog of Medical and Veterinary Zoology edited by Stiles and Hassall. The printing of this work, begun in 1902, has involved to date about 2500 pages for the author lists, which even yet are not finished. Of the subject index one splendid number on Trematoda and Trematode Diseases has already appeared. With the completion of this work, which may be looked for soon as it is progressing with commendable rapidity, the investigator will have at command not only a record of the literature of the past but also a complete subject index admirably arranged and rich in cross references. This will lighten the burden of tracing down the work of his predecessors and at the same time place it at his disposal far more completely than individual effort has been able to cover the field in the past.

Of general literature published on this subject within the past two years the new edition of Braun's Human Parasites easily deserves first place. Besides the addition of a new section on clinical features of parasitic infections it was so thoroly revised otherwise as to be practically a new work and by its translation and publication in English has become accessible to a much wider circle. The laboratory manual on Parasitology by Braun and Lühe also deserves especial mention here. Of practical value for the precise determination of various species of human helminthes is a paper published in these *Transactions* (Ward, 1908a) in which a critical abstract was given of the work during the preceding five years, the discrepancies in the records of different workers were pointed out, and new data furnished for the precise determination of the several species. Another general paper (Ward, 1909) included a brief discussion of the relation of human progress to diseases caused by animal parasites.

PROTOZOA

The last two years have been signalized by the appearance of two admirable general works on the protozoa, which devote especial attention to a consideration of the pathogenic species as well as to the relations of parasitic forms to disease. There are the splendid

text on Protozoology, by G. N. Calkins and the magnificent Lehrbuch der Protozoenkunde by F. Doflein. As a briefer treatise of almost equal importance may be mentioned a chapter by Minchin in Allbutt's System of Medicine, while an article by the author of the present paper (Ward, 1908) gives a brief outline of the present state of knowledge concerning the Protozoa.

So far as parasitic amoebae are concerned the advance in our knowledge has been very great. Many authors have added to the list of known forms new species from man or other animals, but the records have been for the most part so scanty as to afford little positive ground for the acceptance of the views or the identification and determination of the species. Sufficient attention has not been given to extended studies on the life history, and the work of Schaudinn from a previous period has not been materially expanded, although his conclusions have been questioned apparently without sufficient ground by many later workers. It seems probable that the diversity of the amoeban parasitic fauna will be shown to be greater even than the present incomplete records indicate; but without any means of discrimination any efforts to establish a system of classification or to differentiate new forms from the old species will lead to little positive results. Among the many papers on these forms it is difficult to make a selection. To the few noted as showing present tendencies, many others might well be added.

As a result of his investigations Craig (1908) confirms the views of Schandinn as to the presence in man of at least two amoebae, one pathogenic and the other a harmless commensal. The paper includes extensive data on the morphology, reproduction and habits of these forms and on their differential diagnosis.

Craig (1910a) has also published more extended studies on the species *Paramoeba hominis*, which he originally described in 1906 as a parasitic amoeba from the human intestine. He has observed some features in the life history and describes the process of encystment and certain flagellate stages in development. The occurrence of the amoeboid, the encysted, and the flagellate stages at the same time in fecal material renders it easy to differentiate this from other intestinal amoebas. The flagellate stage is readily confused with *Trichomonas hominis* but may be told by the absence of

an undulating membrane, the presence of one flagellum and the spherical form in *Paramoeba hominis*.

Elmassian (1909), Hartmann (1908), and Koidzumi (1909) are among others who have made more precise studies of new intestinal amoebae from man.

In one direction considerable advance has been made. Various efforts towards the cultivation of amoebae under laboratory conditions have resulted in partial success, and the time is at hand when this group of organisms can be handled like bacteria and flagellates under conditions of laboratory experimentation. Prominent among the workers in this line have been Musgrave, Nägler and Walker. In commenting on these experiments it should be added that they have given ground for confusion since they deal only with the most uniform and least easily differentiated stage of existence in the life cycle of the organisms. Futhermore, it still remains to be shown that under artificial conditions these organisms manifest the form and display the activities which they possess under natural conditions. Several authors have suggested that the appearance and habits of the organisms are radically modified by cultural conditions, and that great caution must be exercised in drawing conclusions with reference to their structure and habits in the normal host.

Investigations concerning various trypanosomes have multiplied enormously during the last two years. A mere mention of the most important contributions in this field would exhaust the possible limits of this paper, and the bibliography on the subject for recent years constitutes a substantial volume which has already been mentioned under the publications of the Sleeping Sickness Bureau. Of particular importance may be mentioned the experiments of Nuttall (1908), Breinl and Hindle (1910), and others who have succeeded in transmitting rat trypanosomes through the medium of rat fleas and lice. The early view that the transmission of the trypanosome of sleeping sickness was purely a mechanical transfer has given way under the demonstration that the fly becomes infective only after a longer period and remains infected through a considerable interval of time. Reference is made to details later in this paper.

The cultivation of Trypanosomes in artificial media was first successfully carried out by MacNeal and Novy in 1903, and in

subsequent years these same authors have published many details on the technic and have extended the method from the trypanosomes of the rat to other mammalian species and to those of birds. Other investigators have repeated these experiments with varying succeess but least satisfactorily with the pathogenic species. It has not yet been shown that cultures aid in the differentiation of species or strains, or that it is possible to achieve in any way immunity with the organisms thus grown. Nicolle has also used the method to cultivate the protozoon parasite of infantile splenic anemia, and several authors have recently succeeded in cultivating *Treponema pallidum* in an artificial medium.

Of theoretical interest in considering the origin of trypanosomes is the view of Minchin (1908) whose extensive studies on the group deserve prominent mention. He is of the opinion that their ancestors were flagellates parasitic in the gut of vertebrates and the cysts were taken in with food. Through the alimentary wall they reached the circulatory system. Then ingested by blood sucking insects, they encysted in the gut and with the insect feces came again into the gut of the final host. Or they accommodated themselves to life in the insect gut and wandered into the proboscis, only to be transferred by the bite of the host so that encystment became unnecessary and dropped out. In other than blood sucking insects the flagellates are perhaps neotenic larvae.

Kleine (1909) was the first to demonstrate the infective powers of tsetse flies for trypanosomes after long intervals, and confirmed these findings by repeated experiments. It was impossible to escape the conclusion that *Trypanosoma gambiense* undergoes a developmental cycle in its transmitting agent, *Glossina palpalis*.

Kleine's results were confirmed almost immediately by Bruce who found flies infective after 16, 19 and 22 days. Bruce showed that monkeys of the genus Cercopithecus may be used as test animals for human trypanosomiasis. *Cercopithecus ruber* is most suitable and has the same relation to sleeping sickness as the guinea-pig to tuberculosis. But "inoculation into test animals is an uncertain diagnostic method at the best and the incubation period is long; it is rarely needed in human trypanosomiasis." As a test of the permanence of cure or to indicate promptly any relapse, inoculation into this animal would be most useful.

Kleine infected flies hatched from pupae by feeding them on sick monkeys and then conveying sleeping sickness to healthy monkeys. From his work it appears clear that *Glossina morsitans* is also a transmitter of *Trypanosoma gambiense*. The large number of unsuccessful experiments on hereditary transmission renders its occurrence rather unlikely. Mechanical transmission does not occur after an interval of 18 hours.

On the life history of the trypanosomes, Minchin and Thompson (1910) have published the results of studies in the transmission of *Trypanosoma Lewisi* by the rat flea. They show that the rat flea can transmit the flagellate from infected to non-infected rats, that the transmission takes place by the cyclical and not, so far as present evidence goes, by the direct method. The incubation period for the developmental cycle of the trypanosome covers at least 6 or 7 days.

The Bulletin of the Sleeping Sickness Bureau gives (No. 15, page 89) the following table showing the facts at present known concerning the cyclical development of trypanosomes.

METHODS OF TRYPANOSOME TRANSMISSION SO FAR ASCERTAINED

Species of trypanosome.	Insect.	Duration of non-infective period.	Place of development.	Duration of infectivity.	Observer.
T. Brucei (?)	G. palpalis.	20 days		At least 83 days.	Kleine.
T. gambiense and a trypanosome of dimorphon type.	G. palpalis.	16, 19 and 22 days.	Intestine.	At least 75 days.	Bruce, Hamerton, Bateman and Mackie.
T. gambiense.	G. palpalis.	18 days.	Intestine.		Kleine.
T. cazalboui.	G. palpalis.	7 days.	Probocis.	At least 2½ months.	Bouffard.
T. lewisi.	Ceratophyllus fasciatus.	6 days.	Begins in rectum.	At least 6 weeks.	Minchin and Thomson.

"In the cyclical method" says Minchin, "the invertebrate is more than a suitable instrument in the transmission; it acts as a host in which the parasite establishes itself and maintains the existence of its species." The evidence cited above makes it probable that this method is the usual one in the transmission of trypanosomes and *demonstrates the great importance of the insect transmitters.*

Prowazek (1909) defined carefully the often confused genera Herpetomonas, Crithidia and Trypanosoma, and discussed the morphology and development of the last named genus. The paper contains a wealth of important structural details on these forms.

The work of a number of investigators has shown that trypanosomes acquire a specific chemo-resistance to a certain drug which persists unchanged through long periods. Straines with double or triple resistance may be produced experimentally; even though mixed all such strains remain separate and capable of isolation after repeated passages through infected animals.

Chagas (1909) has discovered a new flagellate which he names *Schizotrypanum Cruzi,* in blood of children of Minas Geraes, Brazil. It is transmitted by a bloodsucking bug, common in the inhabited houses of the region. This bug, *Conorrhinus (megistus?),* is a true host of the flagellate which requires at least eight days to complete its developmental cycle in the insect. The parasite was transmitted experimentally, and in some cases at least by bite of the infected bug, to rabbits, dogs, guinea-pigs and monkeys.

Minchin and Woodcock (1910) have worked on the blood parasites of fishes and by comparison of the minute structure and staining reactions are able to demonstrate essential differences between the nuclei of gregarines and trypanosomes. The nucleus of Halteridium is clearly different from that of a gregarine and on the other hand remarkably like that of the trophonucleus of a trypanosome in being of the karyosomatic type. The immediate conclusions from these results are of primary importance in indicating the closer and more distant relationships of the groups cited. They also speak distinctly against the proposal to remove the group of Haemosporidia from the Sporozoa and place it with the trypanosomes under the Flagellata.

Much work has been done recently on the interesting forms known as spirilla or spirochaetes. Many new species have been described, especially from bivalves where they occur in the crystalline style (Fantham, 1908). Authors still differ widely regarding the structure and relationship of these forms. Some new details regarding the spirochaete parasites of higher form have been determined by the use of dark field illumination, etc., but no agreement is reached as to their systematic position or their methods of reproduction. The number of papers and notes which have appeared on this group is so enormous that it is impossible to give, within the limits at the command of this article, any adequate idea of the work done, but the net results do not include many items of striking general importance, while even among the most able investigators

one finds diametrically opposed views regarding some simple features of structure as well as concerning the existence or non-existence of supposed stages and forms in the life history.

Concerning the spirochaete of syphilis described by Schaudinn the most extended study has been made by Krżysztalowicz and Siedlecki (1908).

They maintain that no flagella are present and an undulating membrane is doubtful; the body is not stiff, though little moveable. Chromatin is distributed through the entire body. Multiplication is by longitudinal division. The so-called microgametes originate by cutting off the ends of elongate individuals, i. e., by transverse division or budding; the role of these microgametes, as also of the forms called macrogametes is left unsettled. The spirochaetes belong to the Flagellata, constituting a special group of Spiroflagellata.

The discovery that relapsing fever is due to an organism of the type of a spirillum or spirochaete falls before the period covered by this paper as also the demonstration that several species of the organism exist which are related individually to fevers of different regions. Much evidence has been accumulated during the past two years on the organisms of this group and their differentiation from each other. Darling (1909) has studied carefully the species which is the cause of the relapsing fever of Panama. He shows that it is distinct from the species *Spirochaeta Obermeieri, Sp. Duttoni* and *Sp. Carteri* though belonging to the same group. The morphology of this species shows considerable variation and no positive identification can be made on morphological grounds. The question of the genetic relationship of these forms is still *sub judice*. Darling considers Spirochaeta as more closely related to the bacteria than to the protozoa.

Among the important studies on haematozoa of various sorts conducted by Balfour (1908) especial mention should be made of his investigations on spirochaetes in fowls. He was able to correct many erroneous and partial observations of previous investigators and to demonstrate an intracorpuscular stage of the spirochaete which in all probability may be regarded as a phase in the life history of the organism. Contemporary and subsequent investigations tend to establish the occurrence of such intracorpuscular stages in the life cycle of all spirochaetes and to regard them as stages leading to the

formation of the very minute bodies out of which a new generation of spirochaetes is evolved after transfer to a new host.

Our knowledge of the distribution and life history as well as of the mutual relationships of the Sporozoa has been greatly extended by the work of Léger. His work deals largely with the lower forms and is too extended to permit of detailed citation in this article.

Patton has published valuable papers on the flagellate and sporozoan parasites of various animals. His experiments at inoculating dogs with *Leishmania Donovani,* the parasite of Kala Azar in man, have demonstrated the non-susceptibility of that host. He favors including this parasite with numerous others in the common genus, Herpetomonas, a procedure which can not find favor with zoologists. In a most lucid manner he discusses recently (1909) the life history of the Kala Azar parasite and its relations to other organisms.

The group of organisms represented by the parasite of Kala Azar has received an important addition in the discovery of a new form by Nicolle (1909).

This species which he names *Leishmania infantum,* is the cause of spenomegaly in children, in Tunis and Southern Italy. It is found in the spleen, liver, bone marrow, but rarely in peripheral blood, either free or in uninuclear leucocytes. In cultures it develops into forms similar to Herpetomonas, which multiply actively by cross fission and form rosettes by agglutination at the flagellar ends. It can be transmitted to apes and dogs, and in his opinion is originally a parasite of the latter.

The organism of Kala Azar has also been studied in culture following the original suggestions of Patton and Christopher. New experiments by Row show that active multiplication in blood-serum cultures at 25-28° C. produces colonies of spindle shaped individuals in 48 hours which become free after formation of a flagellum and manifest two forms, thick and thin. Cultures from old cases of oriental sore develop parasites of a spindle shaped, non-flagellate stage only, and after unequal division produce 4 long and 4 short individuals of which the latter are short-lived. He also discusses the difference between *Helcosoma tropicum* and *Leishmania*

Cummins (in Balfour, 1908) discusses the presence of this parasite in the Sudan, its probable introduction, distribution, and significance.

In 1908 Darling reported a new parasitic protozoon encountered in the Canal Zone. The micro-organism, which he names *Histoplasma capsulatum,* gives rise to a fatal infectious disease, histoplasmosis, among natives of tropical America. The parasite is described in detail but no facts were elucidated concerning its life history or the mode of infection. In a later paper (1909a) Darling gives further data on the morphology of the organism which he describes as small, round, or oval, 1 to 4 microns in diameter, possessing a polymorphus, chromatic nucleus, basophilic cytoplasm and achromatic spaces all enclosed within an achromatic refractile capsule. The form and arrangement of the nuclear chromatin and the lack of a chromatic rod differentiate it from the Leishman Donovan body. It occurs in the endothelial cells of smaller lymph and blood vessels in enormous numbers and causes necroses of liver and lymph nodes, splenomegaly, and pseudo-gramulomata of the lungs and intestines, with ulceration of the latter. The organism may prove to be identical with *Helcosoma Donovani* and in any event appears to be closely related to it.

Cole, Hadley and Kirkpatrick (1910) have published an extensive memoir on blackhead in turkeys, in which they discuss broadly the general topic of avian coccidiosis. Their work is full of important observations on the organisms and their relation to disease. They discuss at length the disease, the gross pathological changes involved and the microscopical findings. They interpret the organism, *Amoeba meleagridis,* originally discovered and investigated by Theobald Smith, as merely a stage in the development of the coccidium to which they attribute the disease. They record the presence of the same coccidium in a large series of avian hosts and also in mice, rats and rabbits ("probably"). Finally they outline the developmental cycle and record a series of experiments in transmission. Such radical modifications in accepted views will require some corroborative evidence before they can be finally accepted. Smith has pointed out very recently that important questions must be answered before the conclusions of Cole and his associates can be accepted.

The sexual forms of the malarial plasmodia from human blood are discussed by Craig (1910) who reports also the effect of quinin upon these sexual stages and finds that their disappearance from the peripheral blood does not indicate their destruction. It seems probable that they are merely driven to the spleen and bone marrow. In any event quinin produces no changes whatever in morphology of the fully developed gametes.

Koch showed in 1908 that in *Babesia (Piroplasma) bigemina* one stage occurs in the eggs of the tick and is transmitted thereby to the second generation of ticks. Carter found that *Spirochaete Duttoni* multiplied in the ova of ticks and thus infected the second generation. In flies this may be the usual or the only method of transmission from one generation of the host to the next.

Extensive experimental researches on the drug treatment of Piroplasma have come from Nuttall's laboratory at Cambridge, England. Other contributions from the same source deal with the development of *Piroplasma canis, P. bovis,* and other species, and with *Theileria parva.*

Hepatozoon perniciosum (n. g., n. sp.) a hemogregamine pathogenic for white rats has been studied by Miller (1908) who finds the sexual cycle in a mite *(Lelaps echidninus).*

The great variety of records concerning the occurrence of Sarcosporidia in man of which only two or three cases are positively known, lends special interest to the report of Darling (1909b) concerning a new case. The author regards it as a chance infection of a species different from those hitherto reported from man, but not definitely determined. The sporozoa disappeared from the muscle fibers of the subject and this probably took place on a date when the sporozoites were observed escaping from their capsule. He concludes that such infection gives rise to little or no discomfort. The case was complicated by intercurrent typhoid fever.

Renewed investigations by Bensen (1909) demonstrate the specific distinctness of *Trichomonas intestinalis* and *Tr. vaginalis.* A study of the life history shows that *Trichomonas intestinalis* throws off its flagella and becomes amoeboid. After encystment a new generation is formed. *Tr. vaginalis* encysts in the flagellate stage and after that becomes amoeboid. The same author (1908) has monographed the genus Lamblia.

Among the ciliates there is to report a careful study of the genus Opalina by Metcalf (1909) who gives a synopsis of the species, a description of the structural features, cysts, sexual forms, and biological characteristics of each species. Infection is direct and easy with all species of Batrachia.

HELMINTHES—GENERAL

Shipley has carried out extensive investigations on the internal parasites of the grouse and related birds. The work was undertaken with a view to ascertaining the cause of grouse disease of the British Isles. Several papers give information concerning the abundance and varieties of the grouse entozoa together with data on their structure. Thus far the life history has not been elucidated. The relations which these parasites bear toward disease is the subject of a special paper (Shipley 1908) in which the author brings together also the results of earlier workers on similar relations between other entozoa and other hosts, including man. On the basis of the evidence collected concerning man he concludes that "the passage of bacteria which set up intestinal disease is immensely aided by any agent which causes a lesion in the mucosa. Such lesions are normally caused in man—by entozoa."

Pratt (1909) has published a careful review of our present knowledge regarding the cuticula and subcuticula of Trematoda and Cestoda. He concludes that the cuticula in these worms is not homologous to the similarly designated layer in segmented worms and arthropods but is the peripheral portion of the parenchyma and is formed by secretions of the latter tissue. He regards the subcuticula as a genetic portion of the same tissue and not as epithelial in origin. The subcuticular cells are regularly absent in the earliest larval stages and often in adults (monogenetic trematodes); they probably form an indifferent embryonic tissue to be specialized in the later growth of the worm.

Our knowledge concerning the geographic distribution of helminthes has been notably widened during the past two years. In addition to articles on separate groups by authors quoted in the special sections of this survey, mention should also be made of work on South African species by L. H. Gough, on Australian species by Georgianna Sweet, on South American species by Daday, on

species from Roumania by N. Léon, on species from Bermuda and Florida by E. Linton and H. S. Pratt, on forms from Central Africa by Balfour, Leiper and Wenyon.

TREMATODA

No doubt the most striking contribution to the structure of the flukes which has been made within recent years is the publication by Goldschmidt (1909) of studies which modify radically our interpretation of various organs in these forms.

As a result of careful and extensive investigation the author claims it is necessary to abandon the old view that the shell gland forms the egg shell. The droplets in the yolk cells are shell-secretion, and the shell material is produced by the so-called vitellaria, while the shell gland secretes a watery substance in which the eggs are suspended in the uterus. The so-called yolk cells play no important part in the nourishment of the young embryo.

Stiles and Goldberger (1910) publish the results of an anatomical study of *Cladorchis Watsoni* from man, renamed *Watsonius Watsoni,* and of allied mammalian species all belonging to the new superfamily Paramphistomoidea, which corresponds to the family Paramphistomidae as previously conceived. Many new points in the morphology of these forms are discussed including a large perisuctorial cavity of varied structure which to these authors is suggestive of a rudimentary body cavity absent by definition in the group of Plathelminthes. The authors use the projection method in demonstrating the organology of these thick-bodied and not easily studied species. In this paper Stiles proposes a new and exceedingly important plan for designating the topography of trematodes under a new terminology which may be outlined in the author's words as follows:

"In brief, longitudinal and transverse straight lines are drawn at the periphery of the various organs; the longitudinal lines bound fields the transverse lines bound zones. Portions of the body bounded by other than straight lines (as that portion bounded by the intestinal ceca) are termed "areas." Organs are then located with reference to these fields, zones, and areas. Thus, the testicular zones may coincide, overlap, abut, or be separate; the testicular fields may coincide, overlap, abut, or be separate. An ovary may be described as in the pretesticular, testicular, or posttesticular zone,

or in the extratesticular, testicular, or intertesticular field; a given organ may be in the prebifurcal zone, preacetabular zone, postacetabular, postovarial, postuterine zone, etc. The body is also divided into five transverse zones, each representing 20 per cent of the body length; these zones, beginning at the oral pole, are called the first, second, third, fourth and fifth. It is believed that by aid of this system, descriptions may be made more exact than they frequently are at present, and that, especially in the case of tabular keys, the system will be found useful. A key to the figured species of distomes is now being formed on this principle; a preliminary study, based upon about 150 illustrations, has thus far been found to be very satisfactory."

Lühe (1909) has brought together all the species of trematodes found in the fresh-water fauna of Germany into an admirable brief systematic manual which will be of great service elsewhere also.

Among taxonomic and distributional studies of trematodes from hosts other than man especial mention must be made of the work of Braun and his coadjutors who have added greatly to our knowledge of the structure and relationships within this group. Similar valuable contributions in this field have been made by Odhner on African species, Lühe on numerous families and genera chiefly of European forms, Lebour and Nicoll on the trematodes of the British Isles and adjacent waters, Dietz on the Echinostomidae, etc. Nicoll (1909) has contributed prominently to our knowledge of the systematic arrangement of the digenetic trematodes. Ssinitzin (1909) has discussed the origin of the trematodes and their methods of reproduction on the basis of his investigations in this field.

Much work has been done in determining the diagnostic features of various known human parasites from this group. This has resulted in marked improvement in the description of known forms and also in the differentiation of new and closely related species. Thus Looss (1907) has demonstrated that under the familiar name *Opisthorchis sinensis* two human parasites have been confused by recent authors. Baelz in 1883 separated them correctly and named them *Distomum innocuum* and *D. endemicum*. Looss now makes a new genus *Clonorchis* to hold both species.

Another instance of advance in knowledge by careful investigation of new material concerns the species *Fasciolopsis Buskii* and

F. Rathouisi. The actual existence of the latter has recently been questioned by Odhner (1909) who was able to subject the original material to re-examination. About the same time, however, with the aid of material collected by Drs. Goddard and Jeffreys in China, Ward established (1909a) the validity of Poirier's species *Distoma Rathouisi* not reported since the original record; errors in the original description were corrected and the differential characters between this and related species were determined. Important data concerning the distribution, frequence, and relation of these species to human disease were quoted from the records of the physicians named. It seems likely that the new species reported by Rodenwaldt (1909) *Fasciolopsis Füllebornii,* is actually identical with the form originally described by Poirier. In fact the author himself calls attention to the similarity between his form and the generic diagnosis given by Odhner for the genus Fasciolopsis. Rodenwaldt reports that in the Marine Hospital at Hamburg an Hindoo evacuated among other worms three to which Odhner's generic diagnosis fits except the coiled form of the much stronger cirrus sac and the lack of coecal sac in the sperm vesicle. The almost round cephalic tip is not plainly set off from the body. A broad flat main excretary vessel extends from the posterior end to the shell gland, dorsal to testes. At regular intervals it gives off paired cross branches, a strong pair in the region of the anterior testes with numerous lateral twigs which go up into the anterior region. At the shell gland the main vessel splits into two branches extending anteriad. The condition of the cirrus sac which in size and volume far surpass that of all known trematodes, supports the view of various authors against Odhner that *D. Rathouisi* cannot simply be rejected.

The life history of various flukes has also received attention. A most important contribution in this field has been made by Ssinitzin (1909a) on the aberrant Gastrostomidae. Among human parasites Garrison and Leynes (1909) have studied the miracidium of *Paragonimus Westermanii* under various physical conditions.

In their experiments when eggs are taken fresh from sputum, the cleavage is not finished; in 15 days after evacuation the miracidia swarm out; the temperature optimum is 25-28° C. Bad water and high temperature delay development and ordinarily 25 to 45 days are necessary for hatching, though this is very variable. Miracidia in egg shells remain alive up to 160 days. High temperature

is very dangerous (37°) but over 15° C. is necessary for development; below 10°C. the movement stops, but the embryo remains alive. Direct sunlight is dangerous and any light is unnecessary for development. Weak saline solution is entirely innocuous but dessication proves rapidly fatal.

Garrison (1908) has also described a new fluke parasitic in man. Ortman (1908) has studied the early development of the fluke embryo and followed in detail the origin of the embryonic membranes and of the various organs.

The discovery of a new human blood fluke in China and Japan which just antedated the limits of our summary has led to extended studies on this organism with a view to determining its distribution and hygienic importance. Prominent among these investigations may be mentioned the work of Tsuchiya (1908) who has published a detailed discussion of *Schistosoma japonicum,* especially in its clinical and pathological aspects. Infection takes place through drinking water and is more frequent in men than in women, and most of all in children of the lower classes. Enlargement of the liver and spleen and swelling of the body due to ascites, are the symptoms. In chronic cases intestinal hemorrhage and general weakness (marasmus) lead to a fatal termination. The parasite is very common in cats and dogs of infected districts. The eggs, deposited in the stomach or intestinal wall by parasites are set free directly into vessels and by rupture of these reach the tissues. The splenic enlargement is caused by waste products of the parasites. The eggs, 85.7x64.3 microns, are smaller than in *S. haematobium,* smooth, never having a spine. The male has no papillae or warts on body. The length of body and size of suckers is much greater than in *S. haematobium,* but variable according to the host. Vitellaria and unpaired crus intestinale of female less extended, uterus and paired crura more so than in *S. haematobium.* The disease is wide-spread in China and the Philippines. Prophylaxis consists in avoidance of impure drinking water. The work of Katsurada and Hashegawa, noted later, throws grave doubts on this last conclusion.

A new species of human blood fluke, *Schistosoma Mansoni,* was established by Sambon in 1907 on the basis primarily of the structure of the ova which possess a lateral spine and also differ in size from the long-known Egyptian species *(S. haematobium)* and the more recently discovered species of the Orient *(S. japonicum).* In

an extended critique Looss (1908) reached the conclusion that the evidence is absolutely insufficient to point out the existence of a distinct species in the West Indies and certain parts of Africa as claimed by Sambon. The latter author (1909) replied in detail to the criticisms of Looss and adduced further evidence to show the correctness of his views regarding the existence of a new species in the regions noted and the distinctness of this species, *S. Mansoni,* from forms described previously.

By the work of Piraja da Silva (1908) many details of structure in the adult worms of *Sch. Mansoni* are reported with such clearness and apparent accuracy that it is difficult to reject his conclusions regarding the existence of this as a distinct species. In 20 cases, all that were observed, only lateral spined eggs were found. Precise and full measurements and descriptions are given for male, female, egg and miracidium and the lateral spined ova were observed in the uterus of the female worm.

In a brief article Looss (1909) after analyzing the views and observations of other investigators regarding the method of infection in Egypt by the blood fluke comes to the following important conclusions:

"The theory of the infection taking place by the mouth(along with food and drink) must be refuted because it is irreconcilable (a) with certain biological peculiarities of the miracidium, (b) with the general distribution of the disease among the population of Egypt.

"The theory of infection by miracidium entering the urethra or the anus is (a) utterly improbable for general parasitological reasons; (b) in contradiction with a number of biological and anatomo-pathological facts (for example the incapability on the part of the miracidium to resist the action of acids, even if very diluted; the part played in the infection by the liver, etc.).

"The theory of infection by the skin is in accordance with all the facts thus far known (a) of the biology of the parasite, (b) of the distribution of the disease among the population (native and foreign, town and rural) of Egypt. It shows (c) how the chief sufferers—the children in town, the adult males in the country—live under conditions which, from the epidemiological point of view, are essentially the same ,and give the miracidia (d) the opportunity of passing, within the short time of their life, from man to water and from water back to man."

This view which Looss has been brought to adopt after long study with many experiments and extended observation on the field has received startling confirmation in recent experiments conducted by Katsurada and Hashegawa (1910). They took young cats and dogs from non-infected regions and exposed them for an hour and a half in the ditch water of infected territory under precautions which rendered infection *per os* impossible. Then followed prompt removal from the infected region. About a month later several thousand blood flukes were present in the bodies of these experimental animals. Two conclusions seem unavoidable: first, the young form of *Schistosoma japonicum* penetrates through the skin into the human as well as the animal body and attains sexual maturity within the limits of a month. Second, the miracidium also develops to a sporocyst and to the adult in the one host and from a few cysts countless young worms are produced. According to a brief supplemental note by these authors, Matsuura has demonstrated eggs in human feces when the infected individual had only waded in the water of infected regions and Fujinami has been able to demonstrate skin infection in cattle also.

CESTODA

Kofoid and Watson (1910) have published a most important preliminary note on the orientation of the adult cestode based on their studies on Gyrocotyle. The morphology of the nervous system leads them to regard the tapeworm scolex as posterior and the free end of the chain as anterior. "It is noteworthy that this orientation of the cestode brings the growing zone in the so-called neck of the strobila into a position homologous with that of the antepenult segment of the amelid worm, also the zone of growth."

The importance of this paper consists in the care with which the view is worked out by the detailed study of the nervous system especially. So far as the theory itself is concerned one should call attention to the fact that these views concerning the orientation of the cestode body are in agreement with those advanced somewhat earlier by Cohn (1907). He based his argument which was presented in the brief form of a preliminary paper on the structure of the adult Cestodaria, on a comparative study of the morphology and development of the onchosphere in different groups of tapeworms, and on a comparison of growth regions in cestodes and annelids.

Young (1908) has investigated with great precision the development of the individual tissues and organs of the common dog tapeworm, *Taenia serrats,* from its bladder worm, *Cysticercus pisiformis.* The origin and multiplication of cells in the early stages of the bladder worm force Young to conclude that the small groups of chromatin granules (chromidia?) assemble to form nuclei at various points. Later these nuclei acquire control of protoplasmic areas which become delimited from surrounding areas as new cells. Nucleoplasm is fundamentally the same as cytoplasm; and in the manner indicated cells may in his opinion originate *de novo.*

Gläser (1909) described the development of the bladder worm of *Taenia crassipes* in great detail. In the main it resembles the well-known development of Echinococeus. La Rue (1909) has worked out some important factors in the development of Proteocephalus and gives the first account of fat tissue in a cestode.

The highly interesting primitive cestode, Archigetes has been studied by Mrázek (1908) who describes a new species and adds comparative data on the structure of those already known. Plehn (1908) has added to these primitive forms, frequently grouped together as Cestodaria, a new genus, Sanguinicola, which is parasitic in the blood stream of the carp.

Gasse (1910) has investigated the local reaction produced in the body of the animal by invasion of the bladder worm. He finds that the host animal envelopes the inwandering Echinococcus or bladder worm with a variously constructed cyst. Fertile Echinococci are almost always surrounded by fibrillar connective tissue. Sterile Echinococci have a three-fold capsule: inside young connective tissue cells, then round cells, outside fibrillar connective tissue. The bladderworm cyst consists of the same tissue elements as the Echinococcus capsule. Giant cells are present only in cysts of sterile Echinococci.

Little has been done on human cestode parasites within the past two years save the publication of brief notes or preliminary descriptions of new species.

Stiles (1908) reported from Florida a proliferating cestode larva found in man which resembles closely the similar human parasite known from Japan. Its most striking characteristic is the production by budding of supernumerary heads which may become independent and wander through the subcutaneous tissue in which

the parasite is found. Nothing is known of the life history, method of infection, or adult form of the parasite.

Stephens (1908) has described *Dibothriocephalus parvus* n. sp. from a Syrian in Tasmania; the parasite is regarded as "possibly a Levantine product after all and not Australian in origin." He also described in the same paper *Taenia Bremneri* n. sp. from a native woman in Northern Nigeria where the parasite was said to be common.

Léon (1908) has described a new human tapeworm from Roumania under the name of *Braunia jassyensis.* Another new form of human cestode, *Diplogonoporus Brauni,* has also been described by Léon (1910) who reports two cases which, like the first species, come from Roumania.

The cestodes of other hosts than man have received considerable attention during the last two years. Among the most important contributions are those of Fuhrmann and Ransom.

Fuhrmann (1908) published a most extensive and valuable monograph on the cestodes of birds including 500 species from 200 host species. The species of cestodes found in birds of different zoogeographical areas are often very distinct. To this he has also added other papers dealing with more recent acquisitions and broadening notably our knowledge of the structure and distribution of these forms.

Ransom (1909) contributed a monograph on bird cestodes of this continent and has thus given the first connected account of these parasites in a region less known in that respect than any other grand division of the earth's surface. He has thus supplied an important gap in our knowledge of the avian parasitic fauna.

Lühe (1909) has published a valuable synopsis of cestodes found in German fresh water hosts.

NEMATODA

The group of Nematoda has always occupied an isolated positon in the animal series and during the past few years numerous attempts have been made by careful microscopic study of the structural details and of developmental history to demonstrate the probable relationships of the group to other branches and also to the aberrant groups which have often been associated with it in the phylum Nemathelminthes. The habits, life history and pathological

significance of the parasitic species have also been investigated with the results of importance for the comprehension of the relations in which these species stand to the causation of disease and for the formulation of rational measures against the spread of these parasites.

Rauther (1909) has brought together the results of his previous studies on the morphology and relationships of the Nematodes with results which are at variance with previous views. The author states at the outset that the structural features, developmental stages, and larval forms of Nematoda furnish no basis for attaching the group to other types of worms but afford everywhere hints of a connection with the Arthropoda. He would associate Gordins and Nectonema with Solenogastridae, though distantly. In the fore gut of Nematoda he finds many points of similarity to the Echinoderidae, the Gastrotricha, the Tardigrada and Pentastomidae, even to the Diptera; and in the opinion of the author all these groups may be traced back phylogenetically to the highly organized Arthropoda.

On the structure of the Nematoda, and of other groups often classed with them as Nemathelminthes, many studies have been published. Of first rank must be mentioned the work of Goldschmidt on the nervous system of Ascaris.

Goldschmidt (1909a) found the nervous system of Ascaris so simple in form, constancy, and symmetry of parts that it could be described in full and every individual cell indicated by a fixed number. Thus for the first time it became possible to depict the complete anatomical foundation for a comprehension of all reflex processes. In these species he was able to demonstrate continuity of protoplasm in the system. These species of nematodes grow not by cell division but by cell enlargement and the adult has in most organs just as many cells as the completed embryo. It is then clear that cell lineage has a mathematical relation to adult structure not previously suspected.

Martini (1909) has finished an important and extensive study on the comparative histology of the subcuticula and lateral lines of nematodes. The embryological history of these structures is carefully followed out and on the basis of this evidence the author draws the following conclusions concerning the classification: the group of Strongylidae is an unnatural one; the terms polymyaria and mero-

myaria are of true systematic value; but coelomyaria and platymyaria are not.

Valuable systematic studies on Nematoda have been made by Railliet et Henry (1909) on the very large and variable family, the Strongylidae; from which, as formerly held, they exclude Eustrongylus, Hystrichis, and Physaloptera as belonging to the Filariidae. The remaining forms can be grouped into Metastrongylinae and Ankylostominae with numerous sub-groups. On the basis of extended studies Jägerskiöld (1909) comes independently to the same conclusion: that the Eustrongylidae constitute a well limited family which has no near relation to the Strongylidae proper.

Glaue published a brief report on the difference between the small dog and cat nematodes (*Ascaris canis and A. felis*) also known as occasional parasites of man. His work in distinguishing these forms as separate species has been anticipated in part by Leiper,* whose original note seems not to have been followed as yet by the more complete discussion promised.

Considerable attention has been paid to the structure and development of the minute blood-inhabiting embryos, known as Microfilariae, which are frequent in certain regions and are assigned a prominent role among human parasites.

Rodenwaldt (1908) has studied the microscopic filarial embryos in the blood. No mutation could be found among the canine filariae. The embryo worms are most common in lungs both in men with mutation and in dogs without it and wander everywhere in blood vessels, even in terminal capillaries but are lacking in lymph vessels. They prefer capillaries of larger vessels and hence are much more frequent in most organs than in the blood stream. It seems that *diurna* is torn away by day in the swift flowing capillary region of the pulmonary circulation whereas at night it withstands the current in this circulation. *Nocturna* is carried on both day and night in the swift flowing capillary stream of the pulmonary circulation, by day also in that of the systemic circulation, whereas it can maintain its place by night in the slower moving capillary blood of the systemic circulation. In the second part are given many topographic details of external body form and internal structure of blood filariae, mainly useful for differential diagnosis of species.

*British Medical Journal, June 1, 1907, p. 1296.

Fülleborn (1908b) gives diagnostic differences between *F. diurna* and *nocturna,* length of life of worms, anatomical details, measurements, and infection of mosquitos.

The same author (1908a) also records experimental work on dogs with *F. immitis.* He further discusses length of life of microfilariae, problems connected with diurnal and nocturnal appearance, whether the mosquito takes up more microfilariae than proportionate to the blood sucked, the development of the microfilariae in various mosquitos, at different temperatures, etc., the migration of the larvae into the proboscis, the stay of the larvae in the mosquito when no blood is taken, the length of life of larvae ripened in the mosquito and kept in various media and finally the penetration of the skin by the larvae.

Noè has demonstrated that for *Filaria Grassii* the intermediate host is *Rhipicephalus sanguineus.* The nymphs suck up the lymph of the dog. The infrequent larvae taken with it pass through the intestinal wall into the lacunom and go through stages of development in any organ or tissue. Even the male tick is a parasite carrier and important for the species on account of its greater mobility. The gravid female gets larvae at the start of sucking when lymph is taken; when blood reaches the stomach the filariae atrophy, losing their power of movement. Then follows a description of the larvae that is very complete.

Fülleborn (1908) has published a detailed description of *Filaria volvulus,* which is common in Kamerun. Several individuals, male and female, lie in a simple subcutaneous tumor. Free larvae are found in the capsule of an older tumor, but have not yet been found in blood. They are easily told from other known blood filariae.

Phalen and Nichols (1909) record the facts concerning filariasis in man and other animals in the Philippines and conclude that since the carrier of the embryo filaria (*Culex fatigans*) is universally distributed, the narrow localization of human infection can only be explained on the mutual exclusion of malarial infection.

Unterberger (1908) shows in one unquestioned case that *Oxyuris vermicularis* does bore into the normal mucosa with its head. In other cases ulceration may have been primary and entrance of the worm secondary.

Wenyon (in Balfour, 1908) conducted some experiments with embryos of the guinea worm, confirming the observations of Leiper that after the embryo has completed its metamorphosis in the cyclops, the addition of very dilute hydrochloric acid kills the entomostracan but causes the embryo to desert actively its dead host. These conditions simulate gastric digestion. After metamorphosis the long pointed tail is replaced by a short, blunt, bilobed tail.

Important contributions have been made to the geographical distribution and systematic arrangement of Nematoda through extensive papers by Jägerskiöld, Shipley and von Linstow.

Stephens (1909) has reported a new nematode, *Strongylus Gibsoni,* as a human parasite from Chinese in Hong Kong. He also furnishes final evidence for excluding *Filaria immitis* from the list of human parasites, printing a letter from Bowlby, the supposed authority for such occurrence which states that the use of this name resulted from the error of a reviewer.

Lühe (1909a) has published a resume of our knowledge concerning the Acanthocephala which from its complete and critical character is certain to form the basis for future work on this group. He reviews the history of investigations in this field from the earliest references to the work of Westrumb in 1821 and then lists all the species included under the genus Echinorhynchus with critical citation of complete data for each species; later he cites those forms originally included under other generic names and finally discusses the genera of Acanthocephala, both those that are deserving of present acceptance and those that are to be rejected as synonyms or on other grounds.

Our scanty knowledge concerning the life history of the Acanthocephala renders the work of Riquier (1909) especially noteworthy; in the pike he produced experimentally the development of *Pomphorhynchus laevis* Zoega *(Echinorhynchus proteus* West.) from *Tinea vulgaris.*

INSECTS

The agency of blood-sucking insects in the transmission of disease has led to extended studies on the determination of species, and on the structure and the life history of such forms. Briefer studies and more extended papers on various species and genera are exceedingly numerous, and monographs on the different groups of mosquitos, flies and ticks are among the most important con-

tributions of recent years. In a recent volume on blood-sucking flies, Austen (1909) completes the British Museum series of monographs on blood-sucking insects which was planned by Lankester. While the record is confessedly incomplete, and the museum material available from the different regions of very unequal value, nevertheless Uganda, which has particular interest in the problem of disease transmission by blood sucking insects, is well treated and the description of binomic features will be of particular value to investigators in the field.

King (in Balfour, 1908) reports on the flies and other blood sucking insects in the Sudan.

The Sleeping Sickness Commission of the Royal Society found as the result of its early investigations that *Glossina palpalis* on the uninhabited shores of Victoria Nyanza can retain its infectivity for a period of at least two years after the native population has been removed. On the basis of the evidence they give, one is forced to conclude either that the fly is long lived or that there is a local reservoir of the disease-producing organism. The view that the crocodile, on the blood of which Glossina feeds, constitutes such a reservoir is not supported by the facts thus far discovered.

Experiments in transmission of animal trypanosomes, as well as *Tr. gambiense,* were made by Bruce (1910) first on lake-shore flies, and later on flies bred in the laboratory. In wild flies the shortest time before one became infected with *Tr. gambiense* was 18 days, the longest 45 days, and the average 32 days. In laboratory bred flies the shortest time was 27 days, the longest 53 and the average 36 days. It was very difficult to infect such flies at all. A wild fly may remain infective at least 75 days.

It appears now probable that sleeping sickness may be conveyed by some other agent than *Glossina palpalis,* some few positive cases being reported from regions, particularly Lake Nyassa, where this fly has never been found. It is hardly likely that the species has been overlooked.

Bruce and others have also shown that mechanical transmission of sleeping sickness by means of *Glossina palpalis* can take place if the transference of the flies from an infected to a healthy animal is instantaneous,—i. e., by interrupted feeding. But this mechanical transmission does not occur if any time interval comes

between the feedings, and it plays a much smaller part, if any, in the spread of sleeping sickness than has been heretofore supposed.

The same authors have proved experimentally that cattle may act as a reservoir of the virus of sleeping sickness, and that healthy animals may be infected from them by means of *Glossina palpalis*. Furthermore, in the fly area cattle do harbor naturally *Trypanosoma gambiense* and may keep up indefinitely the infectivity of the fly, though proof is lacking that in nature such does actually take place.

Complete records have been published of 50 cases of sleeping sickness in Europeans. Of these 30 are known to be dead, 11 survive, and the fate of 9 is uncertain. At least one well known case seems to have made a positive recovery, and there are grounds for like hope in 4 others or more. Their recovery appears to be due to the resisting power of the human organism, at least as much as to the treatment.

Among diseases transmitted by blood sucking insects, sleeping sickness has received primary attention during the last few years, but bubonic plague has taken almost equal prominence in scientific study. Much work has been done under the direction of the United States Marine Hospital Service on our western coast with reference to the occurrence of the fleas and their relation to rats and ground squirrels in which the disease now seems to be endemic. Thus it has been shown that rat fleas, caught in San Francisco, will bite man under experimental conditions, and that squirrel fleas feed readily on human blood. Furthermore, fleas from rodents adapt themselves quickly to hosts of a different species and pass from rat to squirrel and vice versa, even in the presence of their proper hosts. The plague bacilli have been demonstrated in the common squirrel flea and in the lice found regularly on the same host. It is interesting to note that the average number of fleas from the squirrel is larger than from the rat or from any other host yet observed. On the transportation of fleas between distant points by means of ships, rats and mice, one investigation made at Hamburg covering a period of three months, showed that 6% of the rodents examined carried fleas in considerable numbers, and that all but 6% of the fleas were of the species *Pulex cheopis*, a form primarily responsible for the transfer of the plague bacilli. This observation furnished positive evidence that living fleas are

imported from Oriental ports into western harbors; and even in the absence of living rats, or under circumstances when the immigration of rodents from the ship is absolutely prohibited, they may transfer infection and be distributed to various points on shore through personal effects or various articles of freight and baggage.*

In an extended critique and summary of present knowledge, Nuttall (1908a) deals with the importance of various species of ticks, especially in the transmission of protozoal diseases. Among the latter, those due to hematozoal parasites (Piroplasma) take first rank in the severe effects produced among domestic animals. Relapsing fevers in man and similar mammal and fowl diseases due to Spirochaeta, are also tick transmitted. The propagation of Rocky Mountain or Spotted Fever is due to a tick and mention has already been made in this paper of the demonstration that Filaria embryos may undergo their development in a tick which also serves as a means of conveying the infection from one human host to another.

The final report of Ricketts (1909) contains a summary of his work on the spotted fever of Montana and its transmission from which the following items are excerpted as of importance here. The wood tick is the natural means by which man is infected with this disease, to which also some of the small native animals are susceptible. The latter serve as a reservoir for the disease, keeping it alive from year to year. The disease is hereditary in the tick, though this fact alone cannot be responsible for the maintenance of the disease; hereditary transmission occurs probably in less than 50% of the cases under natural conditions. Experiments showed that the rock squirrel, chipmunk, the wood-chuck, and the mountain rat are all also adapted to the maintenance of spotted fever in nature.

Nuttall and his collaborators have published a long series of papers on various factors in the structure and biology of the parasitic ticks. Among them are articles on the presence of an anticoagulin in the salivary glands and intestines of *Argus perscius,* on the structure of tick spiracles, of Haller's organ, on the behavior of spirochaetes in the bed bug (*Acanthia lectularia*) and on the structure and biology of *Haemophysalis punctata.*

*For details and references to literature consult my review on this topic in the American Naturalist, July, 1910, p. 439.

Neumann has continued the well known series of papers on the ticks and has begun also a new series treating of the comparative morphology of the Pediculidae.

Rohr (1909) has contributed an extensive memoir on the Ixodidae of Brazil, including valuable data on their internal microscopic structure and on the biology of the group.

King (in Balfour, 1908) has made an extensive report on the ticks of Central Africa with data concerning hosts, life history and relation to disease.

One of the most important studies in microscopic anatomy published recently is the paper by Stiles (1910) on the microscopic structure of the stigmal plates in Dermacentor. He demonstrates the high systematic value of these plates which afford a simple means for the differentiation of the otherwise variable, often easily confused species.

MAMMALS

The most striking investigations of recent years with reference to the bubonic plague and its relation to the human species have not been those which dealt with the transmitting insects, but rather those which concerned the natural and acquired hosts of the disease among the lower animals. As is well known the bubonic plague is probably primarily a rodent disease and the rodent host is believed by some to be a Mongolian marmot, from which the disease is transmitted through house rats to the human species. In California the disease has become endemic among the ground squirrels which some years ago suffered from a widespread epidemic. It is established on the best of evidence that the disease has been transmitted from the ground squirrel to the human species, and that plague infected rodents still exist on the western coast, although infrequent at present. From the ground squirrel it has spread in exceptional cases to the brush rat and perhaps to other native species. Transmission to the human race can occur usually through the medium of the house rat rather than directly from the native species, although it has been suggested that transfer from the squirrel to man may be brought about through range cattle which acquire the fleas in and about squirrel villages and then through contact with man give opportunity for transfer of the infected insects. It has been suggested also that the booby owl, which occupies the same burrows with the ground squirrel,

may readily carry infected fleas over long distances, infect new squirrel villages and new regions, and thus complicate greatly the problem of the reduction of the disease. The habits of the wood rat militate against the probability that it can play any particular part in infecting the human species.

A most important contribution in the field of medical zoology which is also unique in having been published by a committee of business men, is the record of Plague Eradication in San Francisco (Citizens Health Committee, 1909). Apart from its medical and social importance it contains chapters on the role of the rat and of the flea which present in non-technical form the biological data concerning these species, especially such items as were determined in the course of the work at San Francisco and are related to plague transmission. The report includes full details concerning the means taken for the extermination of the rat and for rat-proofing buildings.

BIBLIOGRAPHY

AUSTEN, E. E.
1909. Illustrations of African Blood Sucking Flies Other than Mosquitoes and Tse Tse Flies. British Museum, London, 221 pp. 13 Pl.

BALFOUR, A.
1908. Third Report of the Wellcome Research Laboratories at the Gordon Memorial College, Khartoum. 477 pp. 48 Pl. 218 Text figs.

BENSEN, W.
1908. Bau und Arten der Gattung Lamblia. Zeit. Hyg., 61:109-114.
1909. Untersuchungen uber *Trichomonas intestinalis* und *vaginalis* des Menschen. Arch. Protistenk., 18:115-127. 3 Pl.

BREINL, A. AND HINDLE, E.
1910. Observations on the Life History of *Trypanosoma Lewisi* in the Rat Louse *(Haematopinus spinulosus)*. Ann. Trop. Med. and Par., 3:553-564. 2 Pl.

BRUCE, SIR DAVID.
1910. The Development of Trypanosomes in Tsetse Flies. Proc. Roy. Soc. B 556, pp. 368-388. —ibid— B 558, pp. 498-501, 480-484.

CALKINS, G. N.
1909. Protozoology. New York. 349 pp. 4 Pl. 123 Text figs.

CHAGAS, C.
1909. Ueber eine neue Trypanosomiasis des Menschen. Mem. Inst. Oswaldo Cruz, Brazil, 1:159-218.

CITIZENS' HEALTH COMMITTEE.
1909. Eradicating Plague in San Francisco. Printed locally. 313 pp. Numerous plates and figures.

COHN, L.
1907. Die Orientirung der Cestoden. Zool. Anz., 32:51-66.

COLE, L. J., HADLEY, P. B., AND KIRKPATRICK, W. F.
1910. Blackhead in Turkeys: a Study in Avian Coccidiosis. R. I. Agl. Exp. Station, Bull. 141. pp. 137-271. 11 Pl.

CRAIG, C. F.
1908. Studies upon the Amebae in the Intestine of Man. Jour. Infec. Diseases, 5:324-377. 2 Pl.
1910. The Sexual Forms of the Malarial Plasmodia Occurring in the Blood of Man. Arch. Int. Med., 5:325-347.
1910a. Further Observations on *Paramoeba hominis,* an Intestinal Parasite of Man. Arch. Int. Med., 6:1-11.

DARLING, S. T.
1909. The Relapsing Fever of Panama. Arch. Int. Med., 4:150-185.
1909a. The Morphology of the Parasite *(Histoplasma capsulatum)* and the Lesions of Histoplasmosis, a Fatal Disease of Tropical America. Jour. Exp. Med., 11:515-531. 5 Pl.
1909b. Sarcosporidiosis with Report of a Case in Man. Arch. Int. Med., Apl. 1909. (Reprint in 7 pp. 1 Pl.).

DOFLEIN, F.
1909. Lehrbuch der Protozoenkunde. Jena, 914 pp. 825 figs.

ELMASSIAN, M.
1909. Sur un nouvelle espèce amibienne chez l'homme, *Entamoeba minuta.* n. sp., 1 re mémoire. C. B. Bakt. u. Par., Orig. 52:335-351. 2 Pl.

FANTHAN, H. B.
1908. *Spirochaeta (Trypanosoma) Balbiani* (Certes) and *Spirochaeta anodontae* (Keysselitz). Quar. Jour. Mic. Sci., 52:1-73. 3 Pl.

FROMME, W.
1909. Ueber das Vorkommen von *Pulex cheopis* auf Schiffsratten und Schiffsmäusen. C. B. Bakt. u. Par., Orig. 52:243-248.

FUHRMANN, O.
1908. Die Cestoden der Vögel. Zool Jahrb., Suppl. 10, Hft. 1.

Fülleborn, Fr.
1908. Ueber Filaria volvulus (Leuckart). Arch. Schiffs.-Tropenhyg., Beihelft 7, 17 pp. 5 Pl.
1908a. Ueber Versuche an Hundefilarien und deren Uebertragung durch Mücken. Arch. Schiffs.-Tropenhyg., Beiheft 8, 43 pp. 4 Pl.
1908b. Untersuchungen an menschlichen Filarien und deren Uebertragung auf Stechmücken. Arch. Schiffs.-Tropenhyg., Beiheft 9, 36 pp. 9 Pl.

GARRISON, P. E.
1908. A new Intestinal Trematode of Man, *Fascioletta ilocana* n. g., n. sp. Phil. Jour. Sci., B 3:385-393. 2 Pl.

GARRISON, P. E. AND LEYNES, R.
1909. The Development of the Miracidium of Paragonimus under various Physical Conditions. Phil. Jour. Sci., Manila, B 4:177-183.

GASSE, R.
1910. Ein Beitrag zur Kenntnis der lokalen Reaktion des Tierkörpers bei Einwanderung von Echinokokken und Finnen. C. B. Bakt. und Par., Orig. 55:30.

Gläser, H.
1909. Zur Entwicklungsgeschichte des *Cysticercus longicollis* Rud. Zeitschr. f. wiss. Zool., 92:540-581. 2 Pl.

GLAUE, H.
1909. Zur Unterscheidung von *Ascaris canis* und *A. felis (Ascaris canis* s. *mystax)* Ein Beitrag zur Systematik der Nematoden. Zool. Anz., 33:785-790.

GOLDSCHMIDT, R.
1909. Eischale, Schalendrüse und Dotterzellen der Trematoden. Zool. Anz., 34:481-498.
1909a. Das Nervensystem von *Ascaris lumbricoides* und *megalocephala.* Ein Versuch in den Aufbau eines einfachen Nervensystems einzudringen, II. Theil. Zeit. f. wiss. Zool., 92:306-357. 3 Pl. (I. Theil. Zeit. f. wiss. Zool. 90:73-136. 3 Pl.).

HARTMANN, M.
1908. Eine neue Dysenterienamoeba. Arch. Schiffs.-Tropenhyg., 12:

Jagerskiöld, L. A.
1909. Zur Kenntnis der Nematoden-Gattungen Eustrongylides und Hystrichis. Nov. Act. Soc. Sci. Upsala, vol. 2, no. 3; 48 pp. 5 Pl.

KATSURADA, F. UND HASHEGAWA, T.
1910. Bemerkungen zur Lebensgeschichte des *Schistosomum japonicum* Katsurada. C. B. Bakt. u. Par., Orig. 53:519-522.

KLEINE, F. K.
1909. Positive Infectionsversuche mit *Trypanosoma Brucei* durch *Glossina palpalis*. Dtsche. Med. Woch., 1909:469-470.

KOFOID, C. A. AND WATSON, E. E.
1910. On the Orientation of Gyrocotyle and of the Cestode Strobila. Proc. Seventh Int. Zool. Congress, Boston. 5 pp.

KOIDZUMI, M.
1909. On a new parasitic Amoeba, *Entamoeba nipponica*, found in the intestine of Japanese. C. B. Bakt. u. Par., Orig. 51:650-654.

KRZYSZTALOWICZ, FR. AND SIEDLECKI, M.
1908. Étude expérimentale de la syphilis; morphologie de *Spirochaeta pallida*. .Bull. Acad. Cracovie, 1908:173-234. 2 Pl.

LA RUE, G. R.
1909. On the Morphology and Development of a New Cestode of the Genus Proteocephalus Weinland. Trans. Amer. Mic. Soc., 29:17-49. 4 Pl.

Léon, N.
1908. Ein neuer menschlicher Cestode. Zool. Anz., 33:359-362.
1910. Un nouveau cas de *Diplogonoporus Brauni*. C. B. Bakt. u. Par., Orig. 55:23-27.

LINTON, E.
1908. Process of Egg Making in a Trematode. Biol. Bull., 14:19-26

Looss, A.
1907. On Some Parasites in the Museum of the School of Tropical Medicine Liverpool. Ann. Trop. Med. and Par., 1:123-151.
1908. What is "*Schistosoma Mansoni*" Sambon 1907? Ann. Trop. Med. and Par., 2:154-191.
1909. Bilharziosis of Women and Girls in Egypt in the Light of the "Skin-Infection Theory." British Med. Jour., Mar. 27, 1909. (Reprint 11 pp.).

Lühe, M.
1909. Parasitische Plattwurmer, I: Trematodes. II: Cestodes. Susswasserfauna Deutschlands. Heft 17, 18.
1909a. Geschichte und Ergebnisse der Echinorhynchen-Forchung bis auf Westrumb (1821). Zool. Annalen, 1:139-353.

MARTINI, E.
1909. Ueber die Subcuticula und Seitenfelder einiger Nematoden. Vergleichend-histologischer Theil. Zeit. f. wiss. Zool., 93:535-624.

METCALF, M. M.
1909. Opalina, Its Anatomy and Reproduction with a Description of Infection Experiments and a Chronological Review of the Literature. Arch. Protistenk., 13:195-375. 15 Pl.

MILLER, W. W.
1908. *Hepatozoon perniciosum* (n. g., n. sp), a Haemogregarine Pathogenic for White Rats. Hygienic Lab. Bull. 46.

MINCHIN, E. A.
1908. Investigations on the Development of Trypanosomes in Tsetse Flies and Other Diptera. Quar. Jour. Mic. Sci., 52:159-260. 6 Pl.

MINCHIN, E. A. AND THOMSON, J. D.
1910. The Transmission of *Trypanosoma Lewisi* by the Rat-flea *(Ceratophyllus fasciatus)*. Proc. Roy. Soc., London, B 555, pp. 273-285.

MINCHIN, E. A. AND WOODCOCK, H. M.
1910. Observations on Certain Blood Parasites of Fishes Occurring at Rovigno. Quar. Jour. Mic. Sci., 55:113-154; 3 Pl.

MOORE, J. E. S. AND BREINL, A.
1909. Life History of *Trypanosoma equiperdum*. Proc. Roy. Soc., London, B 80:288-298. 1 Pl.

Nägler, K.
1909. Entwicklungsgeschtliche Studien über Amoeben. Arch. Protistenk., 15-53. 6 Pl.

Mrázek, Al.
1908. Ueber eine neue Art der Gattung Archigetes. C. B. Bakt. u. Par., Orig. 46:719-723.

NICOLL, WM.
1909. Studies on the Structure and Classification of the Digenetic Trematodes. Quar. Jour. Mic. Sci., 53:391-487. 2 Pl.

NICOLLE, CH.
1909. Le Kala Azar infantile. Ann. Inst. Pasteur, 23:362-401, 441-471. 2 Pl.

Noè, G.
1908. Il ciclo evolutio della *Filaria grassii* mihi, 1907. Atti Accad. Lincei, (5) 17:282-93.

NUTTALL, G. H.
1908. The Transmission of *Trypanosoma Lewisi* by Fleas and Lice. Parasitology, 1:297-301.
1908a. The Ixodidea or Ticks, Spirochaetosis in Man and Animals, Piroplasmosis. Jour. Roy. Inst. Pub. Health, London. 51 pp.

ODHNER, TH.
1909. Was ist *Distomum Rathouisi?* Arch. Parasitol., 12:467-471.

ORTMANN, W.
1908. Zur Embryonalentwickung des Leberegels *(Fasciola hepatica* L) Zool. Jahrb., Anat., 26:255-292. 3 Pl.

PATTON, W. S.
1909. The Parasite of Kala Azar and Allied Organisms. London Lancet, Jan. 30, 1909. (Reprinted in 7 pp. with 2 Pl.).

PHALEN, J. M. AND NICHOLS, H. J.
1909. The Distribution of Filaria in the Philippine Islands. Phil. Jour. Sci., B 4:127-139. 1 map.

PLEHN, M.
1908. Ein monozoischer Cestode als Blutparasit *(Sanguinicola armata* und *inermis* Plehn). Zool. Anz., 33:427-440.

PRATT, H. S.
1909. The Cuticula and Subcuticula of Trematodes and Cestodes. Amer. Nat., 43:705-729.

PROWAZEK, S.
1909. Kritische Bemerkungen zum Trypanosomenproblem. Arch. Schiffs.-Tropenhyg., 13:301-8.

RAILLIET, A. ET HENRY, A.
1909. Sur la classification des Strongylidae: 1. Metastrongylinae. 2. Ankylostominae. C. R. Soc. Biol., Paris, 66:85-88, 168-171.

RANSOM, B. H.
1909. The Taenioid Cestodes of North American Birds. U. S. Nat. Museum, Bull. 60. 141 pp. 42 figs.

RAUTHER, M.
1909. Morphologie und Verwandschaftsbeziehungen der Nematoden und einiger ihnen nahe gestellter Vermalien. Ergeb. Fortschr. Zool., 1: 491-596.

RICKETTS, H. T.
1909. Investigation of the Cause and Means of Prevention of Rocky Mountain Spotted Fever, Carried on during 1907 and 1908. Mont. St. Bd. Health. Fourth Biennial Report, pp. 77-191.

RIQUIER, J. K.
1909. Die Larva von *Pomphorhynchus laevis* Zoega *(=Echinorhynchus proteus* Westr.) in der *Tinea vulgaris* und dessen experimentell erzielte Entwicklung in *Esox lucius.* C. B. Bakt. und Par., Orig. 52:248-

RODENWALDT, E.
1908. Die Verteilung der Mikrofilarien in Körper und die Ursachen des Turnus bei *Microfilaria nocturna* und *diurna.* Studien zur Morphologie der Mikrofilarien. Arch. Schiffs.-Tropenhyg., Beiheft 10, 30 pp. 4 Pl.
1909. *Fasciolopsis Fülleborнii* n. sp. C. B. Bakt. u. Par., Orig. 50:451-461. 1 Pl.

ROHR, C. J.
1909. Estudos sobre Ixodidas do Brazil. Trabalho do Institute Oswaldo Cruz, 220 pp. 5 Pl.

ROW, R.
1909. The Development of the Parasite of Oriental Sore in Cultures. Quar. Jour. Mic. Sci., 53:747-754. 1 Pl.

SAMBON, L. W.
1909. What is *"Schistosoma Mansoni"* Sambon 1907? Jour. Trop. Med. and Hyg., 12:1-11.

SHIPLEY, R. E.
1908. A cause of Appendicitis and Other Intestinal Lesions in Man and Other Vertebrates. Parasitology, 1:263-279.

SILVA, PIRAJA DA.
1908. La Schistosomose a Bahia. Arch. Parasitol., 13:281-

SSINITZIN, D. TH.
1909. Studien über die Phylogenie der Trematoden. 1. Können sich die digenetische Trematoden auf ungeschlechtlichem Wege fortpflanzen? Biol. Zentralb., 29:664-682.
1909a. Studien über die Phylogenie der Trematoden. 2. Bucephalus v. Baer und Cercaria ocellata De la Vall. Zeit. f. wiss. Zool., 94:299-325. 2 Pl.

STEPHENS, J. W. W.
1908. Two new Human Cestodes and a new Linguatulid. Ann. Trop. Med. and Par., 1:547-556. 1 Pl.
1909. A New Human Nematode, *Strongylus gibsoni,* n. sp. Ann Trop. Med. and Par., 2:315-316. 2 Pl.
1909a. On the Supposed Occurrence of *Filaria immitis* in Man. Ann. Trop. Med. and Par., 2:317-320.

STILES, C. W.
1908. The Occurrence of a Proliferating Cestode Larva (*Spargamum proliferum)* in Man in Florida. Hygienic Laby. Bull. 40:7-18.
1910. The Taxonomic Value of the Microscopic Structure of the Stigmal Plates in the Tick Genus Dermacentor. Hygienic Laby. Bull 62; 72 pp. 43 Pl.

STILES, C. W. AND GOLDBERGER, J.
1910. A study of the Anatomy of *Watsonius* (n. g.) *Watsoni* of Man and of nineteen allied species of Mammalian Trematode Worms of the Superfamily Paramphistomoidea. Hygienic Laby. Bull. 60, 264 pp.

TSUCHIYA, J.
1908. Ueber eine neue parasitäre Krankheit (Schistosomiasis japonica) über ihren Erreger und ihr endemisches Vorkommen in verschiedenen Gegenden Japans. Arch. Path. Anat., 193:323-369. 1 Pl.

UNTERBERGER, FR.
1908. Der *Oxyuris vermicularis* in seiner Berziehung zur Darmward und Appendicitis. C. B. Bakt. u. Par., Orig. 47:495-503.

WARD, HENRY B.
1908. Protozoa. Ref. Handbook Med. Sci., Revised Appendix, pp. 634-660.
1908a. Data for the Determination of Human Entozoa, II. Trans. Amer. Mic. Soc., 28:177-202. 2 Pl.
1909. The Influence of Civilization on Human Zoo-parasitic Diseases. Proc. Seventh Int. Zool. Congress, Boston. (Reprint 7 pp.).
1909a. *Fasciolopsis Buskii. F. Rathouisi* and Related Species in China. China Med. Jour.; Also Trans. Amer. Mic. Soc., 29:5-16.

YOUNG, R. T.
1908. The Histogenesis of *Cysticercus pisiformis*. Zool. Jahrb., Anat., 26:183-252. 4 Pl.